

## CHAPTER 6 (Odd)

1. a. 2, 3, 4 in parallel      b. 2, 3 in parallel      c. 2, 3 in series, 1, 4 in parallel

3. a.  $R_T = 9\ \Omega \parallel 18\ \Omega = \frac{9 \cdot 18}{9 + 18} = \frac{162}{27} = 6\ \Omega$

$$G_T = \frac{1}{R_T} = \frac{1}{6\ \Omega} = 0.1667\ \text{S}$$

b.  $G_T = \frac{1}{3\ \text{k}\Omega} + \frac{1}{2\ \text{k}\Omega} + \frac{1}{6\ \text{k}\Omega} = 0.333\ \text{mS} + 0.5\ \text{mS} + 0.167\ \text{mS} = 1\ \text{mS}$

$$R_T = \frac{1}{G_T} = \frac{1}{1\ \text{mS}} = 1\ \text{k}\Omega$$

$$\text{or } 6\ \text{k}\Omega \parallel 3\ \text{k}\Omega = 2\ \text{k}\Omega, 2\ \text{k}\Omega \parallel 2\ \text{k}\Omega = 1\ \text{k}\Omega$$

c.  $R_T = 3.3\ \text{k}\Omega \parallel 5.6\ \text{k}\Omega = \frac{(3.3\ \text{k}\Omega)(5.6\ \text{k}\Omega)}{3.3\ \text{k}\Omega + 5.6\ \text{k}\Omega} = 2.076\ \text{k}\Omega$

$$G_T = \frac{1}{R_T} = \frac{1}{2.076\ \text{k}\Omega} = 0.4817\ \text{mS}$$

d.  $4\ \Omega \parallel 4\ \Omega = 2\ \Omega, 8\ \Omega \parallel 8\ \Omega = 4\ \Omega$

$$R_T = 2\ \Omega \parallel 4\ \Omega = \frac{(2\ \Omega)(4\ \Omega)}{2\ \Omega + 4\ \Omega} = 1.333\ \Omega$$

$$G_T = \frac{1}{R_T} = \frac{1}{1.333\ \Omega} = 0.75\ \text{S}$$

e.  $G_T = \frac{1}{10\ \Omega} + \frac{1}{2\ \text{k}\Omega} + \frac{1}{40\ \text{k}\Omega} = 0.1\ \text{S} + 0.5\ \text{mS} + 0.025\ \text{mS} = 100.525\ \text{mS}$

$$R_T = \frac{1}{G_T} = \frac{1}{100.525\ \text{mS}} = 9.948\ \Omega$$

f.  $R'_T = \frac{9.1\ \Omega}{3} = 3.033\ \Omega, R''_T = \frac{2.2\ \Omega}{2} = 1.1\ \Omega$

$$G_T = \frac{1}{3.033\ \Omega} + \frac{1}{1.1\ \Omega} + \frac{1}{4.7\ \Omega} = 0.3297\ \text{S} + 0.9091\ \text{S} + 0.2128\ \text{S} = 1.4516\ \text{S}$$

$$R_T = \frac{1}{G_T} = \frac{1}{1.4516\ \text{S}} = 0.6889\ \Omega$$

5. a.  $G_T = NG_1 + G_2$

$$\frac{1}{6\ \Omega} = 2 \left[ \frac{1}{18\ \Omega} \right] + \frac{1}{R} \Rightarrow R = 18\ \Omega$$

b.  $G_T = NG_1 + G_2 + G_3$

$$\frac{1}{4\ \Omega} = 2 \left[ \frac{1}{R_1} \right] + \frac{1}{9\ \Omega} + \frac{1}{18\ \Omega}$$

$$0.25\ \text{S} = \frac{2}{R_1} = 0.111\ \text{S} + 0.0556\ \text{S}$$

$$R_1 = 24\ \Omega = R_2$$

7.  $24\ \Omega \parallel 24\ \Omega = 12\ \Omega$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{12\ \Omega} + \frac{1}{120\ \Omega}$$

$$0.1\ \text{S} = \frac{1}{R_1} + 0.08333\ \text{S} + 0.00833\ \text{S}$$

$$0.1\ \text{S} = \frac{1}{R_1} + 0.09167\ \text{S}$$

$$\frac{1}{R_1} = 0.1\ \text{S} - 0.09167\ \text{S} = 0.00833\ \text{S}$$

$$R_1 = \frac{1}{0.00833\ \text{S}} = 120\ \Omega$$

9. a.  $G_T = \frac{1}{3\ \Omega} + \frac{1}{6\ \Omega} + \frac{1}{1.5\ \Omega} = 0.333\ \text{S} + 0.167\ \text{S} + 0.667\ \text{S} = 1.167\ \text{S}$

$$R_T = \frac{1}{G_T} = \frac{1}{1.167\ \text{S}} = 0.857\ \Omega$$

b.  $I_s = EG_T = \frac{E}{R_T} = \frac{0.9\ \text{V}}{0.857\ \Omega} = 1.05\ \text{A}$

$$I_1 = \frac{E}{R_1} = \frac{0.9\ \text{V}}{3\ \Omega} = 0.3\ \text{A}$$

$$I_2 = \frac{E}{R_2} = \frac{0.9\ \text{V}}{6\ \Omega} = 0.15\ \text{A}$$

$$I_3 = \frac{E}{R_3} = \frac{0.9\ \text{V}}{1.5\ \Omega} = 0.6\ \text{A}$$

c.  $I_s \stackrel{?}{=} I_1 + I_2 + I_3$   
 $1.05\ \text{A} = 0.3\ \text{A} + 0.15\ \text{A} + 0.6\ \text{A}$   
 $1.05\ \text{A} \stackrel{\checkmark}{=} 1.05\ \text{A}$

d.  $R_1: P_1 = I_1^2 R_1 = (0.3\ \text{A})^2 3\ \Omega = 0.27\ \text{W}$

$$R_2: P_2 = I_2^2 R_2 = (0.15\ \text{A})^2 6\ \Omega = 0.135\ \text{W}$$

$$R_3: P_3 = I_3^2 R_3 = (0.6\ \text{A})^2 1.5\ \Omega = 0.54\ \text{W}$$

$$P_{\text{del}} = EI_s = (0.9\ \text{V})(1.05\ \text{A}) = 0.945\ \text{W}$$

$$P_{\text{del}} \stackrel{?}{=} P_1 + P_2 + P_3$$

$$0.945\ \text{W} = 0.27\ \text{W} + 0.135\ \text{W} + 0.54\ \text{W}$$

$$0.945\ \text{W} \stackrel{\checkmark}{=} 0.945\ \text{W}$$

e.  $R_1, R_2 \Rightarrow 1/2\ \text{W}, R_3 \Rightarrow 1\ \text{W}$

11. a.  $I = \frac{E}{R} = \frac{120\ \text{V}}{1.8\ \text{k}\Omega} = 66.67\ \text{mA}$

b.  $R_T = \frac{R}{N} = \frac{1.8\ \text{k}\Omega}{8} = 225\ \Omega$

c.  $P = EI = (120\ \text{V})(66.67\ \text{mA}) = 8\ \text{W}$

d. No effect!

13. a.  $R_T = 20\ \Omega \parallel 5\ \Omega = 4\ \Omega$

$$I_s = \frac{E}{R_T} = \frac{30\ \text{V}}{4\ \Omega} = 7.5\ \text{A}$$

$$\text{CDR: } I_1 = \frac{5\ \Omega I_s}{5\ \Omega + 20\ \Omega} = \frac{1}{5}(7.5\ \text{A}) = 1.5\ \text{A}$$

b.  $10 \text{ k}\Omega \parallel 10 \text{ k}\Omega = 5 \text{ k}\Omega$   
 $R_T = 1 \text{ k}\Omega \parallel 5 \text{ k}\Omega = 0.833 \text{ k}\Omega$   
 $I_s = \frac{E}{R_T} = \frac{8 \text{ V}}{0.833 \text{ k}\Omega} = 9.6 \text{ mA}$   
 $R'_T = 10 \text{ k}\Omega \parallel 1 \text{ k}\Omega = 0.9091 \text{ k}\Omega$   
 $I_1 = \frac{R'_T I_s}{R'_T + 10 \text{ k}\Omega} = \frac{(0.9091 \text{ k}\Omega)(9.6 \text{ mA})}{0.9091 \text{ k}\Omega + 10 \text{ k}\Omega} = \frac{8.727 \text{ mA}}{10.9091} = 0.8 \text{ mA}$

15.  $\frac{1}{R_T} = \frac{1}{5 \Omega} + \frac{1}{10 \Omega} + \frac{1}{20 \Omega} = 0.2 \text{ S} + 0.1 \text{ S} + 0.05 \text{ S} = 0.35 \text{ S}$   
 $R_T = \frac{1}{0.35 \text{ S}} = 2.857 \Omega$   
 $P_{\text{del}} = \frac{E^2}{R_T} = \frac{(60 \text{ V})^2}{2.857 \Omega} = 1260 \text{ W}$

17. a.  $I = \frac{24 \text{ V} - 8 \text{ V}}{4 \text{ k}\Omega} = \frac{16 \text{ V}}{4 \text{ k}\Omega} = 4 \text{ mA}$       b.  $V = 24 \text{ V}$

c.  $I_s = \frac{24 \text{ V}}{10 \text{ k}\Omega} + 4 \text{ mA} + \frac{24 \text{ V}}{2 \text{ k}\Omega} = 2.4 \text{ mA} + 4 \text{ mA} + 12 \text{ mA} = 18.4 \text{ mA}$

19. a.  $I_1 = 8 \text{ mA} - 5 \text{ mA} = 3 \text{ mA}$   
 $I_2 = 5 \text{ mA} - 4 \text{ mA} = 1 \text{ mA}$   
 $I_3 = I_1 - 1.5 \text{ mA} = 3 \text{ mA} - 1.5 \text{ mA} = 1.5 \text{ mA}$

b.  $I_2 = 6 \mu\text{A} - 2 \mu\text{A} = 4 \mu\text{A}$   
 $I_3 = 2 \mu\text{A} - 0.5 \mu\text{A} = 1.5 \mu\text{A}$   
 $I_4 = I_2 + I_3 = 4 \mu\text{A} + 1.5 \mu\text{A} = 5.5 \mu\text{A}$   
 $I_1 = I_4 + 0.5 \mu\text{A} = 5.5 \mu\text{A} + 0.5 \mu\text{A} = 6 \mu\text{A}$

21. a.  $R_1 = \frac{E}{I_1} = \frac{10 \text{ V}}{2 \text{ A}} = 5 \Omega$   
 $I_2 = I - I_1 = 3 \text{ A} - 2 \text{ A} = 1 \text{ A}$   
 $R_2 = \frac{E}{I_2} = \frac{10 \text{ V}}{1 \text{ A}} = 10 \Omega$

b.  $E = I_1 R_1 = (2 \text{ A})(6 \Omega) = 12 \text{ V}$   
 $I_2 = \frac{E}{R_2} = \frac{12 \text{ V}}{9 \Omega} = 1.333 \text{ A}$   
 $I_3 = \frac{P}{V} = \frac{12 \text{ W}}{12 \text{ V}} = 1 \text{ A}$   
 $R_3 = \frac{E}{I_3} = \frac{12 \text{ V}}{1 \text{ A}} = 12 \Omega$   
 $I = I_1 + I_2 + I_3 = 2 \text{ A} + 1.333 \text{ A} + 1 \text{ A} = 4.333 \text{ A}$

$$\begin{aligned}
\text{c. } I_1 &= \frac{64 \text{ V}}{1 \text{ k}\Omega} = 64 \text{ mA} \\
I_3 &= \frac{64 \text{ V}}{4 \text{ k}\Omega} = 16 \text{ mA} \\
I_3 &= I_1 + I_2 + I_3 \\
I_2 &= I_s - I_1 - I_3 = 100 \text{ mA} - 64 \text{ mA} - 16 \text{ mA} = 20 \text{ mA} \\
R &= \frac{E}{I_2} = \frac{64 \text{ V}}{20 \text{ mA}} = 3.2 \text{ k}\Omega \\
I &= I_2 + I_3 = 20 \text{ mA} + 16 \text{ mA} = 36 \text{ mA}
\end{aligned}$$

$$\begin{aligned}
\text{d. } P &= \frac{V_1^2}{R_1} \Rightarrow V_1 = \sqrt{PR_1} = \sqrt{(30 \text{ W})(30 \text{ }\Omega)} = 30 \text{ V} \\
E &= V_1 = 30 \text{ V} \\
I_1 &= \frac{E}{R_1} = \frac{30 \text{ V}}{30 \text{ }\Omega} = 1 \text{ A} \\
I_3 &= I_2, \quad I_s = I_1 + I_2 + I_3 = I_1 + 2I_2 \\
2 \text{ A} &= 1 \text{ A} + 2I_2 \\
I_2 &= \frac{1}{2}(1 \text{ A}) = 0.5 \text{ A} \\
I_3 &= 0.5 \text{ A} \\
R_2 = R_3 &= \frac{E}{I_2} = \frac{30 \text{ V}}{0.5 \text{ A}} = 60 \text{ }\Omega \\
P_{R_2} &= I_2^2 R_2 = (0.5 \text{ A})^2 \cdot 60 \text{ }\Omega = 15 \text{ W}
\end{aligned}$$

$$23. \text{ a. } I_1 = \frac{3 \text{ }\Omega(12 \text{ A})}{3 \text{ }\Omega + 6 \text{ }\Omega} = 4 \text{ A}, I_2 = \frac{6 \text{ }\Omega(12 \text{ A})}{3 \text{ }\Omega + 6 \text{ }\Omega} = 8 \text{ A}$$

$$\begin{aligned}
\text{b. } \frac{8 \text{ }\Omega}{2} &= 4 \text{ }\Omega, \frac{6 \text{ }\Omega}{3} = 2 \text{ }\Omega \\
I_1 &= \frac{2 \text{ }\Omega(6 \text{ A})}{2 \text{ }\Omega + 4 \text{ }\Omega} = 2 \text{ A}, I_2 = \frac{4 \text{ }\Omega(6 \text{ A})}{4 \text{ }\Omega + 2 \text{ }\Omega} = 4 \text{ A} \\
I_3 &= \frac{I_1}{2} = \frac{2 \text{ A}}{2} = 1 \text{ A} \\
I_4 &= \frac{I_2}{3} = \frac{4 \text{ A}}{3} = 1.333 \text{ A}
\end{aligned}$$

$$\begin{aligned}
\text{c. } 2 \text{ }\Omega \parallel 3 \text{ }\Omega &= \frac{6}{5} \text{ }\Omega, I_1 = \frac{6/5 \text{ }\Omega(500 \text{ mA})}{6/5 \text{ }\Omega + 1 \text{ }\Omega} = 272.73 \text{ mA} \\
I_2 &= \frac{1 \text{ }\Omega(500 \text{ mA})}{1 \text{ }\Omega + 6/5 \text{ }\Omega} = 227.27 \text{ mA} \\
I_3 &= \frac{2 \text{ }\Omega(I_2)}{2 \text{ }\Omega + 3 \text{ }\Omega} = \frac{2 \text{ }\Omega(227.27 \text{ mA})}{5 \text{ }\Omega} = 90.91 \text{ mA} \\
I_4 &= 500 \text{ mA}
\end{aligned}$$

$$\begin{aligned} \text{d. } V_{18\Omega} &= I_1 R = (4 \text{ A})(18 \Omega) = 72 \text{ V} \\ I_2 &= \frac{V}{R_T} = \frac{72 \text{ V}}{4 \Omega + 12 \Omega} = \frac{72 \text{ V}}{16 \Omega} = 4.5 \text{ A} \\ I_3 &= I_1 + I_2 = 4 \text{ A} + 4.5 \text{ A} = 8.5 \text{ A} \\ I_s &= I_3 = 8.5 \text{ A} \end{aligned}$$

$$25. \quad \text{a. CDR: } I_{6\Omega} = \frac{2 \Omega I}{2 \Omega + 6 \Omega} = 1 \text{ A}$$

$$I = \frac{1 \text{ A}(8 \Omega)}{2 \Omega} = 4 \text{ A} = I_2$$

$$I_1 = I - 1 \text{ A} = 3 \text{ A}$$

$$\text{b. KCL: } I_3 = I = 6 \mu\text{A}$$

$$\text{By inspection: } I_2 = 2 \mu\text{A}$$

$$I_1 = I - 2(2 \mu\text{A}) = 6 \mu\text{A} - 4 \mu\text{A} = 2 \mu\text{A}$$

Since all currents are equal

$$R = 9 \Omega$$

$$27. \quad 68 \text{ mA} = I_1 + I_2 + I_3 = I_1 + 4 I_1 + 3 I_2$$

$$68 \text{ mA} = I_1 + 4 I_1 + 3(4 I_1)$$

$$68 \text{ mA} = I_1 + 4 I_1 + 12 I_1$$

$$68 \text{ mA} = 17 I_1$$

$$I_1 = \frac{68 \text{ mA}}{17} = 4 \text{ mA}$$

$$I_2 = 4 I_1 = 16 \text{ mA}$$

$$I_3 = 3 I_2 = 48 \text{ mA}$$

$$R_1 = \frac{V_{R_1}}{I_1} = \frac{E}{I_1} = \frac{24 \text{ V}}{4 \text{ mA}} = 6 \text{ k}\Omega$$

$$R_2 = \frac{E}{I_2} = \frac{24 \text{ V}}{16 \text{ mA}} = 1.5 \text{ k}\Omega$$

$$R_3 = \frac{E}{I_3} = \frac{24 \text{ V}}{48 \text{ mA}} = 0.5 \text{ k}\Omega$$

$$29. \quad I_{8\Omega} = \frac{16 \text{ V}}{8 \Omega} = 2 \text{ A}$$

$$I = 5 \text{ A} - 2 \text{ A} = 3 \text{ A}$$

$$I_R = 5 \text{ A} + I = 5 \text{ A} + 3 \text{ A} = 8 \text{ A}$$

$$R = \frac{V_R}{I_R} = \frac{16 \text{ V}}{8 \text{ A}} = 2 \Omega$$

$$31. \quad \text{a. } V_L = \frac{4.7 \text{ k}\Omega(9 \text{ V})}{4.7 \text{ k}\Omega + 2.2 \text{ k}\Omega} = \frac{42.3 \text{ V}}{6.9} = 6.13 \text{ V}$$

$$\text{b. } V_L = E = 9 \text{ V}$$

$$\text{c. } V_L = E = 9 \text{ V}$$

$$33. \quad \text{a. } V_2 = \frac{20 \text{ k}\Omega(6 \text{ V})}{20 \text{ k}\Omega + 10 \text{ k}\Omega} = \frac{120 \text{ V}}{30} = 4 \text{ V}$$

b.  $20 \text{ k}\Omega \parallel 11 \text{ M}\Omega = 19.96 \text{ k}\Omega$

$$V_2 = \frac{19.96 \text{ k}\Omega(6 \text{ V})}{19.96 \text{ k}\Omega + 10 \text{ k}\Omega} = \frac{119.76 \text{ V}}{29.96} = 3.997 \text{ V}$$

c.  $R_m = (10 \text{ V})(20,000 \text{ }\Omega/\text{V}) = 200 \text{ k}\Omega$

$$20 \text{ k}\Omega \parallel 200 \text{ k}\Omega = 18.18 \text{ k}\Omega$$

$$V_2 = \frac{18.18 \text{ k}\Omega(6 \text{ V})}{18.18 \text{ k}\Omega + 10 \text{ k}\Omega} = 3.871 \text{ V}$$

(b) more accurate than (c) but both readings in the "neighborhood."

d.  $R_2 \parallel R_m = 200 \text{ k}\Omega \parallel 200 \text{ k}\Omega = 100 \text{ k}\Omega$

$$V_2 = \frac{(100 \text{ k}\Omega)(6 \text{ V})}{100 \text{ k}\Omega + 100 \text{ k}\Omega} = 3 \text{ V}$$

e.  $R_m$  as large as possible (compared to load).

35.  $V_a = 8.8 \text{ V}$  is an incorrect reading.

$$V_{1\text{k}\Omega} = \frac{1 \text{ k}\Omega(12 \text{ V} - 4 \text{ V})}{1 \text{ k}\Omega + 4 \text{ k}\Omega} = \frac{1}{5}(8 \text{ V}) = 1.6 \text{ V}$$

$$V_a = 12 \text{ V} - 1.6 \text{ V} = 10.4 \text{ V}$$

**4 V supply reversed!**

$$V_{1\text{k}\Omega} = \frac{1 \text{ k}\Omega(12 \text{ V} + 4 \text{ V})}{1 \text{ k}\Omega + 4 \text{ k}\Omega} = \frac{1}{5}(16 \text{ V}) = 3.2 \text{ V}$$

$$V_a = 12 \text{ V} - 3.2 \text{ V} = 8.8 \text{ V as indicated}$$

## CHAPTER 6 (Even)

2. a. There are no single elements in parallel.

b.  $R_6$  &  $R_7$ ,  $R_1$  &  $R_3$  and  $E$  are in series.

c.  $R_5 \parallel (R_6 + R_7)$ ,  $R_2 \parallel (R_1 + E + R_3)$

$$4. \quad a. \quad G_T = 0.55 \text{ S} = \frac{1}{4 \Omega} + \frac{1}{R} + \frac{1}{6 \Omega}$$

$$0.55 \text{ S} = 0.25 \text{ S} + \frac{1}{R} + 0.1667 \text{ S}$$

$$0.1333 \text{ S} = \frac{1}{R}$$

$$R = \frac{1}{0.1333 \text{ S}} = 7.5 \Omega$$

$$b. \quad G_T = 0.45 \text{ mS} = \frac{1}{5 \text{ k}\Omega} + \frac{1}{8 \text{ k}\Omega} + \frac{1}{R}$$

$$0.45 \text{ mS} = 0.2 \text{ mS} + 0.125 \text{ mS} + \frac{1}{R}$$

$$R = \frac{1}{0.125 \text{ mS}} = 8 \text{ k}\Omega$$

$$6. \quad \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{20 \Omega} = \frac{1}{R_1} + \frac{1}{5R_1} + \frac{1}{\frac{R_1}{2}} = 1 \left[ \frac{1}{R_1} \right] + \frac{1}{5} \left[ \frac{1}{R_1} \right] + 2 \left[ \frac{1}{R_1} \right] = 3.2 \left[ \frac{1}{R_1} \right]$$

$$\text{and } R_1 = 3.2(20 \Omega) = 64 \Omega$$

$$R_2 = 5R_1 = 5(64 \Omega) = 320 \Omega$$

$$R_3 = \frac{1}{2}R_1 = \frac{64 \Omega}{2} = 32 \Omega$$

$$8. \quad a. \quad R_T = 8 \text{ k}\Omega \parallel 24 \text{ k}\Omega = 6 \text{ k}\Omega$$

$$G_T = \frac{1}{R_T} = \frac{1}{6 \text{ k}\Omega} = 0.167 \text{ mS}$$

$$b. \quad I_s = \frac{E}{R_T} = \frac{48 \text{ V}}{6 \text{ k}\Omega} = 8 \text{ mA}$$

$$I_1 = \frac{48 \text{ V}}{8 \text{ k}\Omega} = 6 \text{ mA}$$

$$I_2 = \frac{48 \text{ V}}{24 \text{ k}\Omega} = 2 \text{ mA}$$

$$c. \quad I_s = I_1 + I_2$$

$$8 \text{ mA} = 6 \text{ mA} + 2 \text{ mA}$$

$$8 \text{ mA} \stackrel{\checkmark}{=} 8 \text{ mA}$$

$$d. \quad P_1 = I_1^2 R_1 = (6 \text{ mA})^2 8 \text{ k}\Omega = (36 \times 10^{-6})(8 \times 10^3) = \mathbf{0.288 \text{ W}}$$

$$P_2 = I_2^2 R_2 = (2 \text{ mA})^2 24 \text{ k}\Omega = (4 \times 10^{-6})(24 \times 10^3) = \mathbf{96 \text{ mW}}$$

$$P_{\text{del}} = EI_s = (48 \text{ V})(8 \text{ mA}) = \mathbf{384 \text{ mW}}$$

$$P_{\text{del}} \stackrel{?}{=} P_1 + P_2$$

$$384 \text{ mW} = 288 \text{ mW} + 96 \text{ mW}$$

$$384 \text{ mW} \checkmark = 384 \text{ mW}$$

e. both 1/2 W

$$10. \quad a. \quad G_T = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2.2 \text{ k}\Omega} + \frac{1}{4.7 \text{ k}\Omega} + \frac{1}{6.8 \text{ k}\Omega}$$

$$= 0.4545 \text{ mS} + 0.2128 \text{ mS} + 0.1471 \text{ mS} = \mathbf{0.8144 \text{ mS}}$$

$$R_T = \frac{1}{G_T} = \frac{1}{0.8144 \text{ mS}} = \mathbf{1.2279 \text{ k}\Omega}$$

$$b. \quad I_s = \frac{E}{R_T} = \frac{12 \text{ V}}{1.2279 \text{ k}\Omega} = \mathbf{9.7728 \text{ mA}}$$

$$I_1 = \frac{E}{R_1} = \frac{12 \text{ V}}{2.2 \text{ k}\Omega} = \mathbf{5.4545 \text{ mA}}$$

$$I_2 = \frac{E}{R_2} = \frac{12 \text{ V}}{4.7 \text{ k}\Omega} = \mathbf{2.5532 \text{ mA}}$$

$$I_3 = \frac{E}{R_3} = \frac{12 \text{ V}}{6.8 \text{ k}\Omega} = \mathbf{1.7647 \text{ mA}}$$

$$c. \quad I_s = I_1 + I_2 + I_3$$

$$9.7728 \text{ mA} = 5.4545 \text{ mA} + 2.5532 \text{ mA} + 1.7647 \text{ mA}$$

$$9.7728 \text{ mA} \checkmark = 9.7724 \text{ mA}$$

$$d. \quad P_1 = I_1^2 R_1 = (5.4545 \text{ mA})^2 2.2 \text{ k}\Omega = \mathbf{65 \text{ mW}}$$

$$P_2 = I_2^2 R_2 = (2.5532 \text{ mA})^2 4.7 \text{ k}\Omega = \mathbf{31 \text{ mW}}$$

$$P_3 = I_3^2 R_3 = (1.7647 \text{ mA})^2 6.8 \text{ k}\Omega = \mathbf{21 \text{ mW}}$$

$$P_{\text{del}} = EI_s = (12 \text{ V})(9.7728 \text{ mA}) = \mathbf{117.27 \text{ mW}}$$

$$P_{\text{del}} = P_1 + P_2 + P_3$$

$$117.27 \text{ mW} = 65 \text{ mW} + 31 \text{ mW} + 21 \text{ mW}$$

$$117.27 \text{ mW} \checkmark = 117 \text{ mW}$$

e. all 1/2 W



12. a. Branch 1:  $I = \frac{P}{E} = \frac{10(60 \text{ W})}{120 \text{ V}} = 5 \text{ A}$   
 Branch 2:  $I = \frac{P}{E} = \frac{400 \text{ W}}{120 \text{ V}} = 3\frac{1}{3} \text{ A}$   
 Branch 3:  $I = \frac{P}{E} = \frac{360 \text{ W}}{120 \text{ V}} = 3 \text{ A}$
- b.  $I_s = I_1 + I_2 + I_3 = 5 \text{ A} + 3\frac{1}{3} \text{ A} + 3 \text{ A} = 11\frac{1}{3} \text{ A}$  No
- c.  $R_T = \frac{E}{I_s} = \frac{120 \text{ V}}{11\frac{1}{3} \text{ A}} = 10.59 \Omega$
- d.  $P_{\text{del}} = EI_s = (120 \text{ V}) \left( 11\frac{1}{3} \text{ A} \right) = 1360 \text{ W}$   
 $P_{\text{del}} = P_1 + P_2 + P_3$   
 $1360 \text{ W} = 600 \text{ W} + 400 \text{ W} + 360 \text{ W}$   
 $1360 \text{ W} \checkmark = 1360 \text{ W}$
14.  $I_{R_2} = \frac{12 \text{ V}}{6 \Omega} = 2 \text{ A}, I_{R_1} = 6 \text{ A} - 2 \text{ A} = 4 \text{ A}$   
 $R_1 = \frac{V_{R_1}}{I_{R_1}} = \frac{E}{I_{R_1}} = \frac{12 \text{ V}}{4 \text{ A}} = 3 \Omega$
16. a.  $8 \Omega \parallel 12 \Omega = 4.8 \Omega, 4.8 \Omega \parallel 4 \Omega = 2.182 \Omega$   
 $I_1 = \frac{24 \text{ V} + 8 \text{ V}}{2.182 \Omega} = 14.67 \text{ A}$
- b.  $P_4 = \frac{V^2}{R} = \frac{(24 \text{ V} + 8 \text{ V})^2}{4 \Omega} = 256 \text{ W}$
- c.  $I_2 = I_s = 14.67 \text{ A}$
18. a.  $12 \text{ A} + 9 \text{ A} + 4 \text{ A} - I_1 = 0$   
 $I_1 = 25 \text{ A} \rightarrow$   
 $I_1 + 4 \text{ A} - 6 \text{ A} - I_2 = 0$   
 $I_2 = 25 \text{ A} + 4 \text{ A} - 6 \text{ A} = 23 \text{ A} \searrow$   
 $I_2 - 3 \text{ A} - I_3 = 0$   
 $I_3 = 23 \text{ A} - 3 \text{ A} = 20 \text{ A} \checkmark$
- b.  $20 \text{ A} - 9 \text{ A} - I_1 = 0$   
 $I_1 = 11 \text{ A} \rightarrow$   
 $I_1 - 5 \text{ A} - I_2 = 0$   
 $I_2 = 11 \text{ A} - 5 \text{ A} = 6 \text{ A} \rightarrow$   
 $I_2 + 8 \text{ A} - I_3 = 0$   
 $I_3 = 6 \text{ A} + 8 \text{ A} = 14 \text{ A} \downarrow$   
 $I_3 - 4 \text{ A} - I_4 = 0$   
 $I_4 = 14 \text{ A} - 4 \text{ A} = 10 \text{ A} \downarrow$

20.  $I_{R_2} = 5 \text{ mA} - 2 \text{ mA} = 3 \text{ mA}$   
 $E = V_{R_2} = (3 \text{ mA})(4 \text{ k}\Omega) = 12 \text{ V}$   
 $R_1 = \frac{V_{R_1}}{I_{R_1}} = \frac{12 \text{ V}}{(9 \text{ mA} - 5 \text{ mA})} = \frac{12 \text{ V}}{4 \text{ mA}} = 3 \text{ k}\Omega$   
 $R_3 = \frac{V_{R_3}}{I_{R_3}} = \frac{12 \text{ V}}{2 \text{ mA}} = 6 \text{ k}\Omega$   
 $R_T = \frac{E}{I_T} = \frac{12 \text{ V}}{9 \text{ mA}} = 1.333 \text{ k}\Omega$
22.  $I_2 = \frac{4 \text{ }\Omega}{12 \text{ }\Omega} I_1 = \frac{1}{3} I_1 = 2 \text{ A}$   
 $I_3 = \frac{4 \text{ }\Omega}{2 \text{ }\Omega} I_1 = 2 I_1 = 12 \text{ A}$   
 $I_4 = \frac{4 \text{ }\Omega}{40 \text{ }\Omega} I_1 = \frac{1}{10} I_1 = 0.6 \text{ A}$   
 $I_T = I_1 + I_2 + I_3 + I_4 = 6 \text{ A} + 2 \text{ A} + 12 \text{ A} + 0.6 \text{ A} = 20.6 \text{ A}$
24. a.  $I_1 \cong \frac{9}{10}(10 \text{ A}) = 9 \text{ A}$   
b.  $I_1/I_2 = 10 \text{ }\Omega/1 \text{ }\Omega = 10$ ,  $I_3/I_4 = 100 \text{ k}\Omega/1 \text{ k}\Omega = 100$   
c.  $I_2/I_3 = 1 \text{ k}\Omega/10 \text{ k}\Omega = 100$ ,  $I_1/I_4 = 100 \text{ k}\Omega/1 \text{ }\Omega = 100,000$   
d.  $\frac{1}{R_T} = \frac{1}{1 \text{ }\Omega} + \frac{1}{10 \text{ }\Omega} + \frac{1}{1 \text{ k}\Omega} + \frac{1}{100 \text{ k}\Omega} = 1 + 0.1 + 0.001 + 10 \times 10^{-6}$   
 $= 1.10101 \text{ S}$   
 $R_T = \frac{1}{1.10101 \text{ S}} = 0.9083 \text{ }\Omega$   
 $V = IR_T = (10 \text{ A})(0.9083 \text{ }\Omega) = 9.083 \text{ V}$   
 $I_1 = \frac{V}{R_1} = \frac{9.083 \text{ V}}{1 \text{ }\Omega} = 9.083 \text{ A vs. } 9 \text{ A}$   
e.  $I_4 = \frac{V}{R_4} = \frac{9.083 \text{ V}}{100 \text{ k}\Omega} = 90.83 \text{ }\mu\text{A}$   
 $\frac{I_1}{I_4} = \frac{9.083 \text{ A}}{90.83 \text{ }\mu\text{A}} = 100,000 \text{ as above}$
26.  $60 \text{ mA} = I_1 + I_2 = 3I_2 + I_2 = 4I_2$   
and  $I_2 = \frac{60 \text{ mA}}{4} = 15 \text{ mA}$   
 $I_1 = 3I_2 = 3(15 \text{ mA}) = 45 \text{ mA}$   
 $V_1 = V_2$   
 $(45 \text{ mA})(2.2 \text{ k}\Omega) = (15 \text{ mA})(R)$   
 $R = \frac{45 \text{ mA}}{15 \text{ mA}}(2.2 \text{ k}\Omega) = 3(2.2 \text{ k}\Omega) = 6.6 \text{ k}\Omega$

$$\text{or } \frac{I_1}{I_2} = \frac{R}{2.2 \text{ k}\Omega}$$

$$\text{and } \frac{3I_2}{I_2} = \frac{R}{2.2 \text{ k}\Omega} \Rightarrow R = 3(2.2 \text{ k}\Omega) = \mathbf{6.6 \text{ k}\Omega}$$

$$\begin{aligned} 28. \quad I_{8\Omega} &= \frac{12 \text{ V}}{8 \Omega} = 1.5 \text{ A}, \quad I_{56\Omega} = \frac{12 \text{ V}}{56 \Omega} = 0.214 \text{ A} \\ I_2 &= I_{8\Omega} + I_{56\Omega} = 1.5 \text{ A} + 0.214 \text{ A} = \mathbf{1.714 \text{ A}} \\ I_1 &= \frac{I_2}{2} = \mathbf{0.857 \text{ A}} \end{aligned}$$

$$\begin{aligned} 30. \quad a. \quad I_s &= \frac{E}{R_T} = \frac{12 \text{ V}}{0.1 \text{ k}\Omega + 10 \text{ k}\Omega} = \frac{12 \text{ V}}{10.1 \text{ k}\Omega} = \mathbf{1.188 \text{ mA}} \\ V_L &= I_s R_L = (1.188 \text{ mA})(10 \text{ k}\Omega) = \mathbf{11.88 \text{ V}} \end{aligned}$$

$$b. \quad I_s = \frac{12 \text{ V}}{100 \Omega} = \mathbf{120 \text{ mA}} \qquad c. \quad V_L = E = \mathbf{12 \text{ V}}$$

$$32. \quad a. \quad I_1 = \frac{20 \text{ V}}{4 \Omega} = 5 \text{ A}, \quad I_2 = 0 \text{ A} \qquad b. \quad V_1 = 0 \text{ V}, \quad V_2 = \mathbf{20 \text{ V}}$$

$$c. \quad I_s = I_1 = \mathbf{5 \text{ A}}$$

34. Not operating properly!  
6 k $\Omega$  resistor not part of configuration (open at one or both terminals)

$$\begin{aligned} R_T &= \frac{6 \text{ V}}{3.5 \text{ mA}} = 1.714 \text{ k}\Omega \\ R_T &= 3 \text{ k}\Omega \parallel 4 \text{ k}\Omega = 1.714 \text{ k}\Omega \end{aligned}$$

36. a. Connection at either end or 1 k $\Omega$  resistor opened up.  
b. -4 V source connected as +4 V